Seismic refraction and electrical resistivity tests for fracture induced hydraulic anisotropy in a mountain watershed

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Where groundwater systems are underlain by crystalline bedrock, such as granite, the bedrock is often considered an impermeable barrier to vertical flow. However, if the bedrock is fractured, permeability can be greatly enhanced and may be anisotropic; the permeability in this scenario depends on both fracture density and orientation. Similarly, seismic primary wave (P-wave) velocity and electrical conductivity are sensitive to fracture density and orientation and have the potential to inform our understanding of hydraulic permeability and anisotropy. Geophysical research in mountain watershed hydrologic processes has been increasing in recent years. However, most studies leave aside fracture induced anisotropy. The Dry Creek Experimental Watershed (DCEW), located near Boise, Idaho, has been subject of several hydrologic studies. Despite the extensive work, the subsurface hydraulic system is not yet well understood, particularly the deep bedrock controlled portion of the system. The study of the deeper system (>5m) is difficult using solely conventional hydrologic measurements. In previous studies, it was concluded that there is a system of fractures, aligned according to local stress field. To test fracture alignment, we collected seismic and electrical resistivity profiles, along four different azimuths. The preliminary results show an azimuthal dependence of the P-wave velocities in the bedrock, at depths greater than 18 m; P-wave velocities range in the slow and fast directions are 3500 and 4100 m/s respectively, which represents a 17.5 % difference. We interpret this difference to be caused by preferentially aligned fractures present in the bedrock. At the same location, preliminary results show an electric resistivity value of 98.9 ohm-m, when measuring ridge perpendicular, and 117.9 ohm-m, ridge parallel, which represents a 19.2 % difference. These results are consistent with an apparent fracture density of 0.41 and a fracture alignment parallel to the ridge. This architecture likely has a significant influence on deep groundwater cycling in this system.